TDC1004

Analog Output, Digital Correlator
64-bit

The TRW TDC1004 is a 64-bit digital correlator with a current source analog output. The device consists of three 64-bit, independently-clocked shift registers capable of a shift speed of 15MHz and a parallel correlation rate of 10MHz.

Correlation takes place when two binary words are serially shifted into the A and B registers. The two words are continually compared, bit for bit by exclusive-NOR (XNOR) circuits. Each XNOR circuit controls a current source. The current output of each current source is then summed to produce the correlation current that is proportional to the degree of correlation.

The third 64-bit shift register (M register) is provided to allow the user to mask or selectively choose "no compare" bit positions.

Features

- 10MHz Correlator Speed
- 15MHz Shift Speed (Static Shift Registers)
- Current Output
- Mask Register
- TTL Compatible
- Available In 16 Lead Ceramic DIP
- Radiation Hard
- 700mW Power Consumption

Applications

- Image Comparison/Recognition
- Bit/Word Synchronization
- Key Word Detection
- Error Correction Coding
- Radar And Sonar

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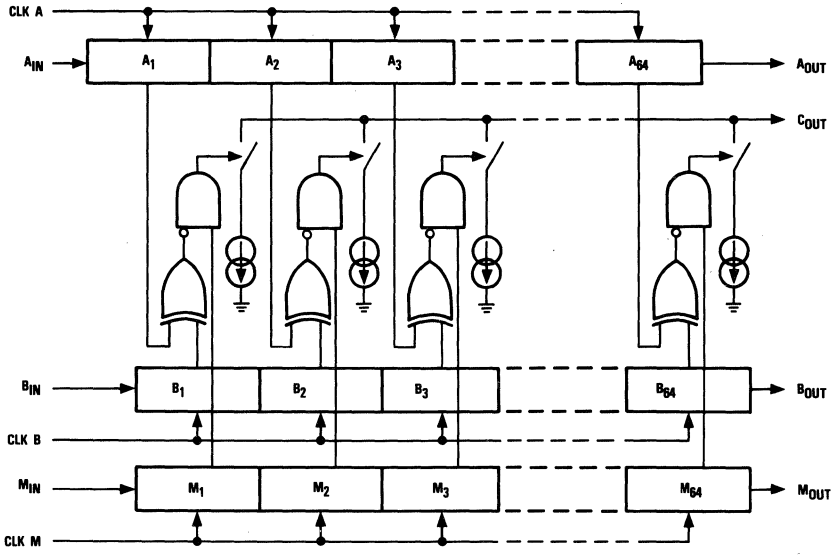
Functional Block Diagram



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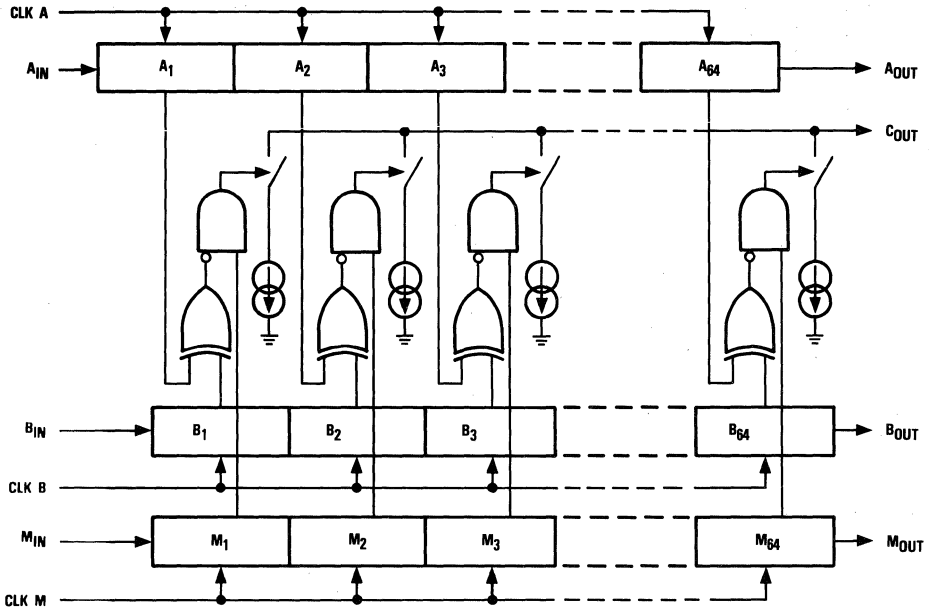
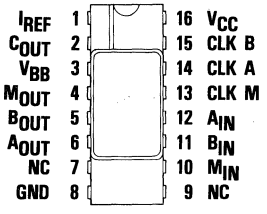
Functional Block Diagram



Pin Assignments



16 Lead DIP – J9 Package

Functional Description

General Information

The TDC1004 has three 64-bit long shift registers: A,B and M. Shift registers A and B are bit-by-bit XNORed (gate provides a true output if the two inputs are the same). The 64 results are then bit-by-bit ANDed with the M register. Each of the outputs of the AND gates are used to turn on one of the 64 equally weighted current sources whose outputs are summed to provide the analog correlation output.

Reference

The TDC1004 provides an output current of:

$I_{OUT} = N \times I_{BIT} + I_{COZ}$

where I_{BIT} is the individual bit output current, N is the number of correlating bits and I_{COZ} is the offset current.

By adjustment of I_{REF} as described in the calibration procedure, the mean bit current variation can be zeroed. I_{REF} is a current input. The voltage at this pin may vary from device to device due to input impedance variations.

Name	Function	Value	J9 Package
I_{REF}	Reference Current	350 μA	Pin 1

Correlation Output

The output of the TDC1004 is a current source at pin 2. The output stage consists of the collector of an NPN transistor whose base is connected to V_{BB}; it is therefore critical that the voltage at the output pin be kept 1.5V to 2.5V above V_{BB} to avoid saturation of this output transistor. V_{BB} should be set to a voltage level of V_{CC} + 1V ± 0.3VDC.

Name	Function	Value	J9 Package
C_{OUT}	Analog Output	300 to 3028 μA	Pin 2
V_{BB}	Base Bias Voltage	6V	Pin 3

Power

The TDC1004 operates from a +5.0V supply. A bias voltage of +6.0V is also required. Since less than 100 μA are drawn this supply, a separate supply is not necessary and the V_{BB} can be provided by the circuit shown in Figure 6.

Name	Function	Value	J9 Package
V_{CC}	Supply Voltage	+5V	Pin 16
V_{BB}	Secondary Supply Voltage	+6V	Pin 3
GND	Electrical Ground	0V	Pin 8

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Clocks

CLK A, CLK M, CLK B — Clock input pins for the A, M, and B registers, respectively. Each register may be independently clocked.

Name	Function	Value	J9 Package
CLK A	A Register Clock	TTL	Pin 14
CLK M	M Register Clock	TTL	Pin 13
CLK B	B Register Clock	TTL	Pin 15

Data Inputs

M_{IN} — Input to the M register. Allows the user to choose "no compare" bit positions. A "0" in any bit location will result in a no-compare state for that location.

A_{IN}, B_{IN} — Input to the A and B 64-bit serial shift registers.

Name	Function	Value	J9 Package
M_{IN}	Mask Register Input	TTL	Pin 10
A_{IN}	Shift Register Input	TTL	Pin 12
B_{IN}	Shift Register Input	TTL	Pin 11

Data Outputs

B_{OUT}, A_{OUT}, M_{OUT} — Outputs of the three 64-bit serial shift registers: B, A, and M, respectively.

Name	Function	Value	J9 Package
B_{OUT}	Shift Register B Output	TTL	Pin 5
A_{OUT}	Shift Register A Output	TTL	Pin 6
M_{OUT}	Shift Register M Output	TTL	Pin 4

No Connects

There are two leads labeled no connect (NC), which have no connections to the chip. These leads may be connected to ground for increased noise reduction.

Name	Function	Value	J9 Package
NC	No Connect	GND	Pins 7, 9

Figure 1. Timing Diagram

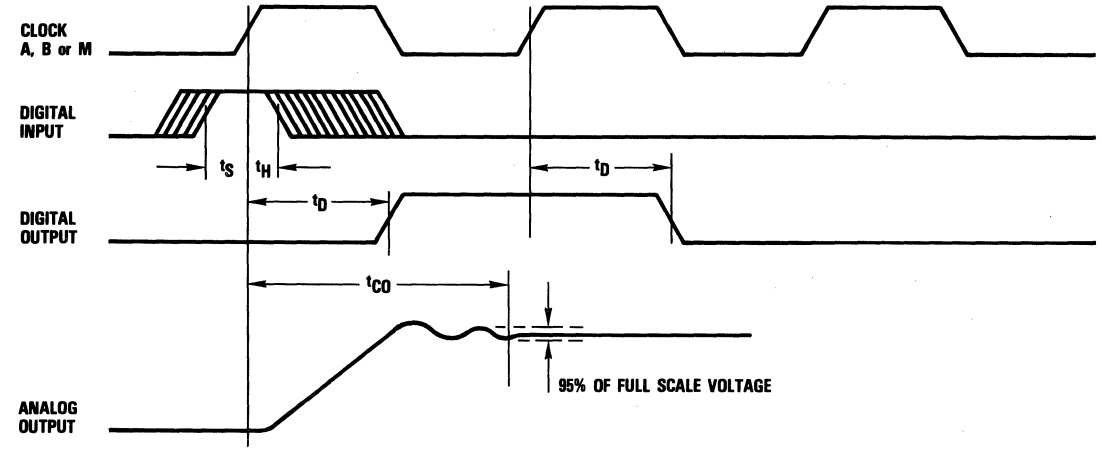


Figure 2. Analog Output Test Load

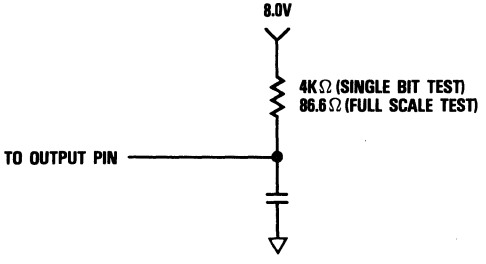
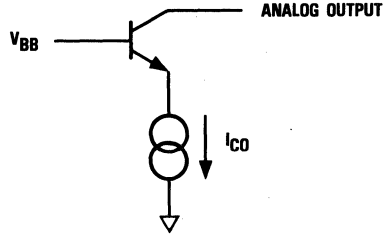


Figure 3. Analog Output Equivalent Circuit



Absolute maximum ratings (beyond which the device will be damaged) [1]

Supply Voltage	−0.5 to +7.0V
Current Source	
Reference signal, I_{REF}	5.0 mA
Input Voltage	
Data and Clock	0.0 to 5.5V
Output Voltage	
Digital outputs, A_{OUT}, B_{OUT}, M_{OUT}	0.0 to 5.5V
Analog output, C_{OUT}	V_{BB} to 8.5V
Applied voltage	−0.5 to 5.5V [2]
Applied current, externally forced	−1.0 to 6.0mA [3,4]
Short-circuit duration (single output in HIGH state to ground)	1 sec
Temperature	
Operating, ambient	−55 to +150°C
junction	+175°C
Lead, soldering (10 seconds)	+300°C
Storage	−65 to +150°C

Notes:

1. Absolute maximum ratings are limiting values applied individually while all other parameters are within specified operating conditions. Functional operation under any of these conditions is NOT implied.
2. Applied voltage must be current limited to specified range.
3. Forcing voltage must be limited to specified range.
4. Current is specified as conventional current flowing into the device.

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Operating conditions

Parameter		Temperature Range						Units
		Standard			Extended			
		Min	Nom	Max	Min	Nom	Max	
V_{CC}	Positive Supply Voltage	4.75	5.0	5.25	4.5	5.0	5.5	V
V_{BB}	Secondary Supply Voltage	5.7	6.0	6.3	5.7	6.0	6.3	V
I_{REF}	Reference Current		320	350		320	350	μA
V_{CO}	Analog Output Voltage	6.5	V_{BB}+2V	8.5	6.5	V_{BB}+2V	8.5	V
I_{COFS}	Full-Scale Analog Output Current	2.73		3.03	2.73		3.03	mA
t_{PW}	Clock Pulse Width	20			20			ns
t_S	Input Register Set-Up Time	20			20			ns
t_H	Input Register Hold Time	10			10			ns
V_{IL}	Input Voltage, Logic Low			0.8			0.8	V
V_{IH}	Input Voltage, Logic High	2.0			2.0			V
I_{OL}	Output Current, Logic Low			4.0			4.0	mA
I_{OH}	Output Current, Logic High			−400			−400	μA
$V(I_{REF})$	Current Reference Voltage		2.2			2.2		V
T_A	Ambient Temperature, Still Air	0		70				°C
T_C	Case Temperature				−55		125	°C

Electrical characteristics within specified operating conditions[1]

Parameter		Test Conditions		Temperature Range: Standard Min	Standard Max	Extended Min	Extended Max	Units
I_{CC}	Supply Current	V_{CC} = MAX			130		130	mA
$I(V_{BB})$	Secondary Suppiy Current				100		100	μA
V_{OL}	Output Voltage, Logic LOW	V_{CC} = MIN, I_{OL} = 4.0mA			0.5		0.5	V
V_{OH}	Output Voltage, Logic HIGH	V_{CC} = MIN, I_{OH} = −0.4mA		2.4		2.4		V
I_{IL}	Input Current, Logic LOW	V_{CC} = MAX, V_{IL} = 0.4V	Clock		−4.0		−4.0	mA
			Data		−0.8		−0.8	mA
I_{IH}	Input Current, Logic HIGH	V_{CC} = MAX, V_{IH} = 2.4V	Clock		200		200	μA
			Data		50		50	μA
I_{BIT}	Single−Bit Analog Output (Delta)	See Note 2		37	43	37	43	μA
I_{COZ}	Zero Correlation Analog Output (Offset)	See Note 2		300	340	300	340	μA

Notes:

1. Test conditions: V_{CC}, V_{BB}, I_{REF} = NOM, measured under DC conditions.
2. After calibration to I_{COFS} (Full−Scale Analog Output Current).

Switching characteristics within specified operating conditions

Parameter		Test Conditions	Temperature Range: Standard Min	Standard Max	Extended Min	Extended Max	Units
t_{CO}	Analog Output Delay	See Figure 2		100		100	ns
t_D	Digital Propagation Delay	See Figure 1		65		65	ns
F_{SI}	Maximum Clock Frequency	Analog output	10		10		MHz
		Digital outputs	15		15		MHz

Application Notes

The TDC1004 is a 64-bit digital correlator with current source analog output. The device performs a bit-for-bit exclusive-OR correlation. In a mathematical sense the TDC1004 performs a convolution on 1-bit words which can be expressed in the general form:

$$y(k) = \sum_{n=1}^{N} k(n) \bullet x(n - k) \qquad \left[\begin{array}{l}\text{Logical 1} = +1 \\ \text{Logical 0} = -1\end{array}\right]$$

In some applications it may be useful to utilize the output current to generate a voltage source for threshold triggering. When converting the output to a voltage, insure that the voltage at the output pin remains above V_{BB} in order to avoid saturation of the output transistor. It is recommended that the voltage at C_{OUT} be in the range of 7.5V to 8.5V for a 6.0V V_{BB}. Two methods for achieving this are shown below:

Figure 4.

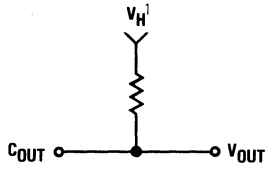
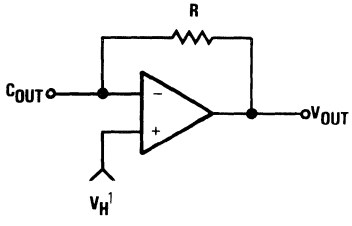


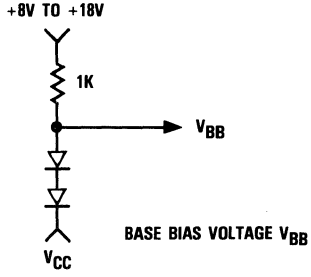
Figure 5.



Note: 1. $7.5V < V_H < 8.5V$

V_{BB} may be provided by the circuit shown below:

Figure 6.



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Calibration

The TDC1004 requires two supplies (V_{BB} and V_{CC}) and a reference current source (I_{REF}) for proper operation. The voltage at the I_{REF} pin will vary from part to part due to differences in input impedance; hence, the source will be specified as a current source. The analog output current will be directly proportional to I_{REF}; therefore it is necessary to scale I_{REF} to minimize output error due to variations.

The total output current (I_{CON}) is equal to the number of correlation bits (N) times the individual bit currents (I_{BIT} = 40μA ± 3μA) plus the offset current (I_{COZ} = 320μA ± 20μA).

Therefore, the total output current can be expressed as:

$I_{CON} = N \times I_{BIT} + I_{COZ}$

As noted in the electrical characteristics, I_{BIT} and I_{COZ} vary separately over the temperature range; thus, by using the following procedure, I_{REF} can be adjusted to yield a statistically zero mean input current variation.

Calibrate I_{REF} as follows:

1) Set V_{BB} at V_{CC} + 1 ± 0.3V
2) Set I_{REF} to 320μA
3) Measure I_{COZ} (zero correlation analog output current)
4) Measure I_{COFS} (full scale correlation analog output)
5) Reset I_{REF} to:

$$* \text{ New } I_{REF} = \frac{2.56\text{mA}}{(I_{COFS} - I_{COZ})} \times \text{Old } I_{REF}$$

*This procedure may be done iteratively by taking the new I_{REF} and repeating steps 3 through 5.

Ordering Information

Product Number	Temperature Range	Screening	Package	Package Marking
TDC1004J9C	STD-T_A = 0°C to 70°C	Commercial	16 Lead DIP	1004J9C
TDC1004J9G	STD-T_A = 0°C to 70°C	Commercial with Burn-In	16 Lead DIP	1004J9G
TDC1004J9F	EXT-T_C = -55°C to 125°C	Commercial	16 Lead DIP	1004J9F
TDC1004J9A	EXT-T_C = -55°C to 125°C	MIL-STD-883	16 Lead DIP	1004J9A
TDC1004J9N	EXT-T_C = -55°C to 125°C	Commercial with Burn-In	16 Lead DIP	1004J9N